Check List the journal of biodiversity data
NOTES ON GEOGRAPHIC DISTRIBUTION

New records of sawflies (Hymenoptera, Symphyta) feeding on leaves of birch (*Betula* sp.) in Slovakia

Šimon Marko[1], Ján Macek[2], Marko Prous[3,4], Ladislav Roller[5]

1 *Department of Zoology, Comenius University, Ilkovičova 6, Bratislava, 841 04 Slovakia*
2 *Department of Entomology, National Museum, Václavské náměstí 68, Prague, 110 00, Czech Republic*
3 *Museum of Natural History, University of Tartu, Vanemuise 46, Tartu, 510 03, Estonia*
4 *Ecology and Genetics Research Unit, University of Oulu, PO. Box 3000, Oulu, FI-90014, Finland*
5 *Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 9, Bratislava, 845 06, Slovakia*

Corresponding author: *Ladislav Roller (ladislav.roller@savba.sk)*

Abstract. New data on the distribution of 11 Symphyta species phyllophagous on birch trees (*Betula* L.) are presented. *Dineura viridorsata* (Retzius, 1783), *Heterarthrus nemoratus* (Fallén, 1808), *Nematinus caledonicus* (Cameron, 1882), *Pamphilius varius* (Audinet-Serville, 1823), and *Pristiphora alpestris* (Konow, 1903) are reported from Slovakia for the first time. The little-known *Allantus cingillum* (Klug, 1814), *Euura ampla* (Konow, 1895), *E. leionota* (Benson, 1933), *Profenusa thomsoni* (Konow, 1886), *Trichiosoma lucorum* (Linnaeus, 1758), and *T. vitellina* (Linnaeus, 1761) were found in Slovakia, either after many decades or for the second time.

Key words. Central Europe, Cimbicidae, distribution, molecular analysis, Pamphiliidae, Tenthredinidae

Marko Š, Macek J, Prous M, Roller L (2025) New records of sawflies (Hymenoptera, Symphyta) feeding on leaves of birch (*Betula* sp.) in Slovakia. Check List 21 (1): 45–56. https://doi.org/10.15560/21.1.45

INTRODUCTION

Thanks to its geographical location and geological structure, Slovakia offers a wide variety of biotopes, which are inhabited by a great diversity of organisms. This diversity is reflected in the rich fauna of Symphyta (Hymenoptera), so far comprising 695 species and 12 families (Roller and Haris 2008; Goulet et al. 2015; Roller and Macek 2017; Balázs and Haris 2019a, 2019b; Liston et al. 2019a; Macek et al. 2020; Roller et al. 2022; Balázs and Haris 2023; Roller and Kočíšek 2023). However, the estimated total species number for Slovakia is more than 900 (Holý et al. 2016), indicating a large research deficit. This is confirmed by the recently published first records of some species (e.g. Balázs and Haris 2023) and the discovery of a new taxon (Roller and Kočíšek 2023). Furthermore, the Symphyta fauna of Slovakia lacks some species that are known from neighbouring countries and may, therefore, have been overlooked. Such missing species are usually associated with plants that have not yet been thoroughly sampled. One such plant in Slovakia is the birch genus (*Betula* L.) with two species native to the country: *B. pendula* Roth and *B. pubescens* Ehrh. In Central Europe, 58 species of Symphyta are known whose host plants are birches (Lacourt 2020; Macek et al. 2020). However, only 41 species have been recorded from Slovakia so far, and there are no recent records for many of them (Roller and Haris 2008; Roller and Macek 2017; Balázs and Haris 2023). In this study, we present the first records of some Symphyta species for Slovakia and add new distribution data for little-known taxa whose larvae feed on birch leaves.

OPEN ACCESS

Academic editor: Filippo Di Giovanni
Received: 7 October 2024
Accepted: 23 December 2024
Published: 10 January 2025

Copyright © The authors. This is an open-access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0)

METHODS

In the years 2020 to 2024, several sites where birch trees (*Betula* sp.) occur were visited (Table 1). In the field, adult sawflies were caught with entomological nets, transferred to a tube filled with 96% ethanol, then stored at -20 °C for future molecular analyses. The larvae were collected with a beating tray or individually (e.g. from mines) and then either preserved in 96% ethanol or placed alive in plastic containers. The live larvae were fed with leaves of the host plant under field conditions. After the larvae had reached the eonymph stage, they were placed in containers with various substrates (soil, peat, and rotten wood) for pupation, overwintered outdoors, and checked daily the following spring for emerged adults.

Most species were identified using the identification keys by Macek et al. (2020) and Lacourt (2020). The nomenclature of the Symphyta was taken from the Electronic World Catalogue of Symphyta (ECatSym) (Taeger et al. 2018). Unless otherwise stated, the data on species distribution are taken from Taeger et al. (2018), Lacourt (2020), and Macek et al. (2020). Voucher specimens are kept in the Department of Zoology of the

Table 1. Characteristics of the studied sites in Slovakia.

Geographic area	Locality, sampling site	Geographic coordinates	Altitude (m) a.s.l.	Habitat	Betula sp. sampled
Borská nížina lowland	Mešterova lúka	48°28′34.42″N, 017°03′31.90″E	175	Acidophilous oak–birch and pine–birch woods	*B. pubescens*
Borská nížina lowland	Orlovské vŕšky	48°27′49.15″N, 017°03′06.59″E	182	Acidophilous oak–birch and pine–birch woods	*B. pubescens*
Kremnické vrchy Mts.	Kremnické Bane env., Zadná mokraď	48°44′15.64″N, 018°53′47.26″E	785	Birch swamp forest	*B. pubescens*
Kremnické vrchy Mts.	Kremnické Bane env.	48°43′41.81″N, 018°54′26.66″E	780	Shrubby clearing	*B. pubescens*
Kremnické vrchy Mts.	Kremnický štít Mt.	48°41′45.53″N, 018°56′44.55″E	952	Hedgerow on mountain pasture	*B. pubescens*
Kremnické vrchy Mts.	Kremnica env.	48°41′45.43″N, 018°55′13.25″E	612	Hedgerow on mesophilic meadow	*B. pubescens*, *B. pendula*
Kremnické vrchy Mts.	Jastrabá env	48°38′40.34″N, 018°55′27.69″E	490	Fringe of oak–hornbeam forest	*B. pubescens*
Vysoké Tatry Mts.	Tatranská Lomnica env.	49°09′50.53″N, 020°17′40.86″E	813	Acidophilous spruce–birch forest	*B. pubescens*
Poloniny Mts.	Uličské Krivé env.	48° 59′10.02″N, 022°26′58.96″E	350	Hedgerow on mesophilic meadow	*B. pubescens*

Faculty of Natural Sciences of Comenius University (DZFNSCU) and the Institute of Zoology of the Slovak Academy of Sciences in Bratislava (IZSAS).

For DNA barcoding, a small piece of muscle tissue (preferably from the leg) was taken from a captured or reared individual (larvae and adults). DNA extraction was performed with the PrepGem Universal Kit (MicroGEM). Sequences of approximately 700 bp of the COI gene region were obtained using the standard barcoding primer sets LCO1490 and HCO2198 (Folmer et al. 1994). The PCR reaction was performed in a total volume of 25 µl using DreamTaq Green PCR Mastermix (ThermoFisher Scientific). The PCR protocol for the COI gene fragment and verification of the quality of the PCR products follows the work of Kúdelová et al. (2022). The final PCR product was then purified using a GeneJET PCR Purification Kit (ThermoFisher scientific) and sent for either commercial Sanger sequencing or in a few cases using Nanopore sequencing (methods described by Prous et al. in press). The sequences obtained were aligned and adjusted using Geneious Prime 2024.0.3 bioinformatics software. Subsequently the sequences were then analysed and published in the GenBank database or in the BOLD Systems database.

Images of live larvae and leaf mines were taken with a Nikon Coolpix P7700 camera. Preserved specimens were scanned using a Leica M205C stereomicroscope and a Leica Flexacam C1 camera, including operating software with a Z-stack projection tool. Maps were created with QGIS 3.34.3 software (QGIS.org 2024) using base maps from Natural Earth (2024) and from the Atlas krajiny Slovenskej Republiky (2013), which are accessible online.

Abbreviations and symbols used: L = larvae, ♂ = adult male, ♀ = adult female, ŠM = Šimon Marko, LR = Ladislav Roller.

RESULTS

During the search for birch-associated sawflies, which have not yet been recorded in Slovakia, 11 species of three Symphyta families were found. Five of these species were recorded in Slovakia for the first time. Another six species were found for the second time, or many decades after the last previous records, which confirms their current presence in Slovakia.

Family Pamphiliidae

Pamphilius varius (Serville, 1823)

Figures 1A, B, 2A

Material examined. SLOVAKIA – Bratislava region • Borská nížina lowland; Mešterova lúka; 48°28′34.42″N, 017°3′31.90″E; 175 m alt.; 13.V.2023; LR lgt.; GenBank PP651608; 1♀, S18_DZFNSCU.

Distribution. First record from Slovakia. Palaearctic species. Europe, Great Britain, Ireland, Siberia, North and South Korea, Japan.

Remarks. This is a univoltine species whose adults occur in April and May. The larva lives in a leaf roll and feeds on *Betula* leaves. It is considered local and uncommon in the Czech Republic (Macek et al. 2020). We collected a single female by tapping branches of *Betula pubescens* in an acidophilous pine–birch forest bordering a wetland.

Identification. Adults of this species are easily recognized by their colouration and the glossy vertex with shallow and sparse punctation (Figure 1A, B). The most similar *Pamphilius albopictus* (Thomson, 1871), *P. kon-*

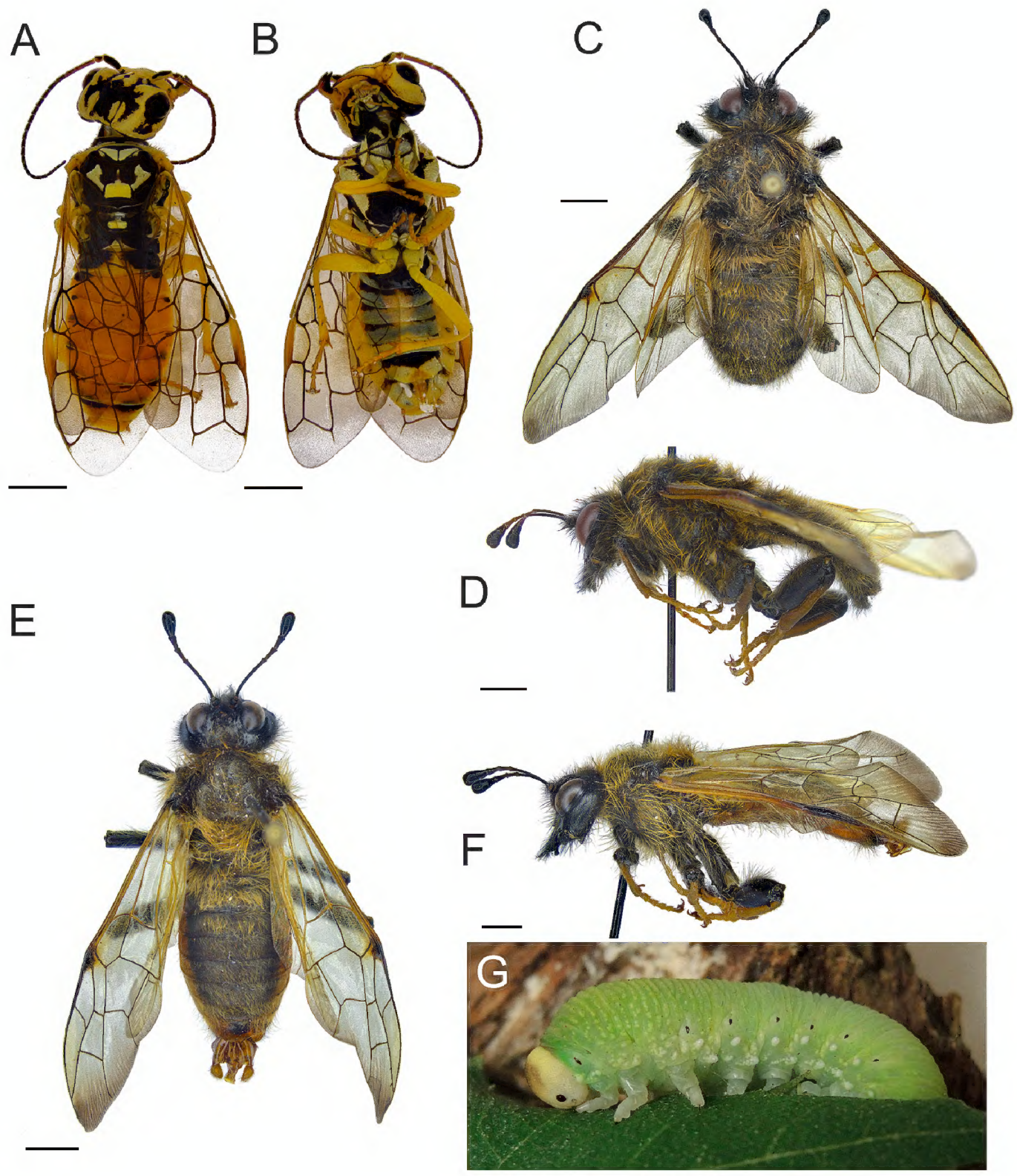

Figure 1. Habitus of the species of *Pamphilius* Latreille, 1803 and *Trichiosoma* Leach, 1817 found in birch trees in Slovakia. **A, B.** *Pamphilius varius* (Serville, 1823). **A.** Dorsal view. **B.** Ventral view. **C, D.** *Trichiosoma lucorum* (Linnaeus, 1758). **C.** Dorsal view. **D.** Lateral view. **E–G.** *Trichiosoma vitellina* (Linnaeus, 1761). **E.** Dorsal view. **F.** Lateral view. **G.** Mature feeding larval instar. Scale bars = 2 mm.

tuniemii Shinohara, 2003, and *P. vafer* (Linnaeus, 1767); all have a vertex with coarse, dense punctation. Most of the abdominal terga are mainly orange-yellow, which distinguishes *P. varius* from *P. pallipes*, the other pamphiliid species associated with *Betula* in Central Europe (Lacourt 2020; Macek et al. 2020). The identification is confirmed by the barcode obtained (GenBank accession PP651608), which clearly distinguishes this species from other representatives of the genus known in Europe.

Family Cimbicidae

***Trichiosoma lucorum* (Linnaeus, 1758)**
Figure 1C, D, 2B

Material examined. SLOVAKIA – Bratislava region • Borská nížina lowland; Orlovské Vŕšky; 48°27′49.15″N, 017°3′6.59″E; 182 m alt.; 25.III.2023; LR lgt.; 1♂, LR140_IZSAS.
LR140_IZSAS reared from the larva collected on 21.V.2022.

Distribution. Newly recorded from Slovakia. Palaearctic species. From the British Isles, through Central and Northern Europe, Mongolia, Russia to Siberia, North and South Korea, Japan.

Remarks. This robust clubhorn sawfly is rarely collected as an adult in Central Europe, but its larvae are more often found on the branches of *Betula*, where they feed solitarily on leaves. Therefore, the species is considered common and widespread in the Czech Republic (Macek et al. 2020). In Slovakia, however, this species was only mentioned in historical records from the 20th century (Starhrad in the Malá Fatra Mountains and Sninský kameň in the Poloniny Mountains) (Chyzer 1901; Roller and Haris 2008). We reared a single male from a larva found on *Betula pubescens* in an acidophilous oak–birch forest, thus confirming the current occurrence of the species in Slovakia.

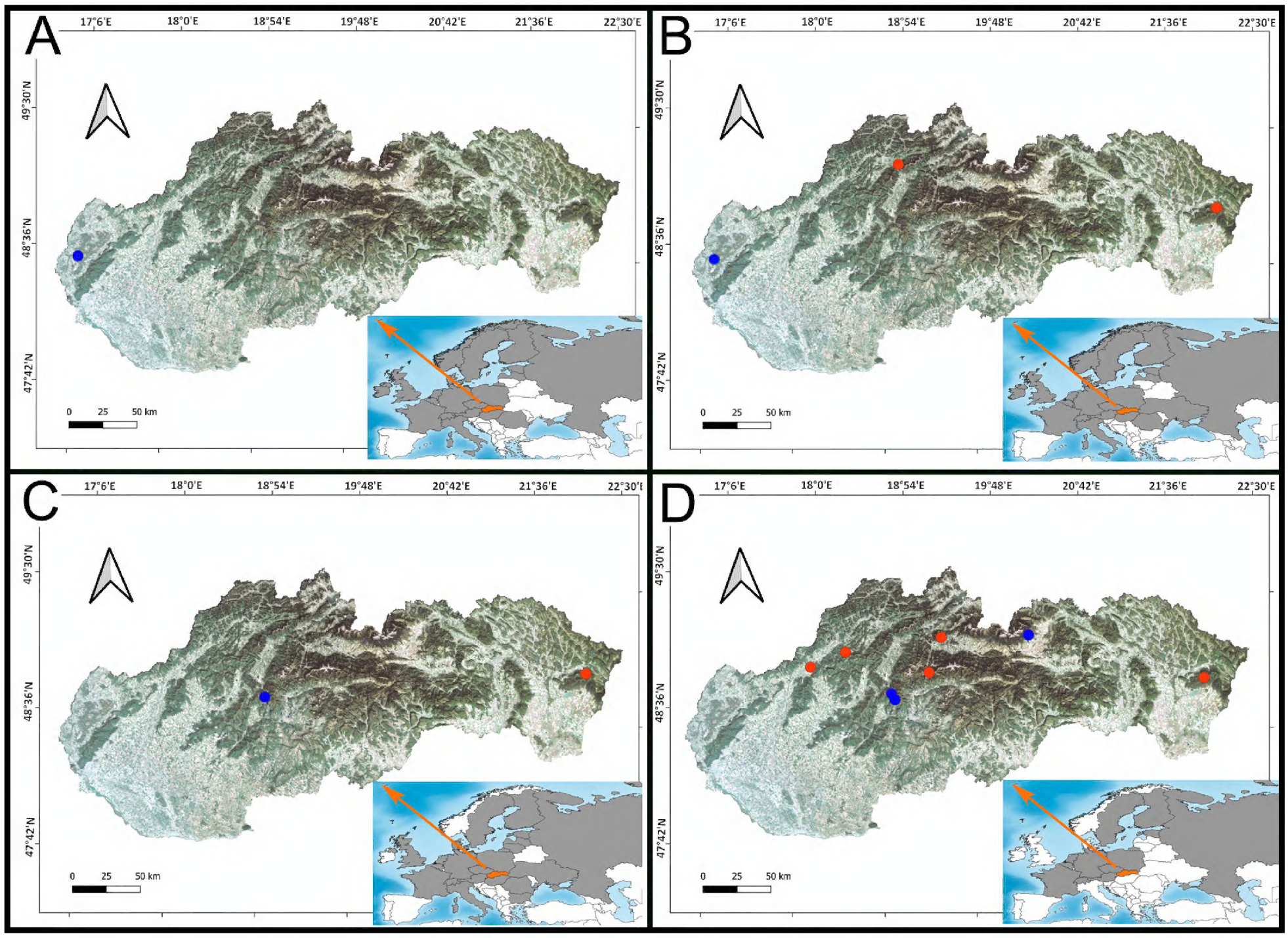

Figure 2. Geographical distribution of four Symphyta species in Europe with detailed distribution maps of Slovakia. **A.** *Pamphilius varius* (Serville, 1823). **B.** *Trichiosoma lucorum* (Linnaeus, 1758). **C.** *Trichiosoma vitellina* (Linnaeus, 1761). **D.** *Allantus cingillum* (Klug, 1818). Countries with published record are highlighted in grey. Previously published record (red circle). New record (blue circle). Data from: Roller and Haris (2008); Taeger et al. (2018); Macek et al. (2022).

Identification. The European species of *Trichiosoma* Leach, 1817 are difficult to identify due to the unresolved synonymy, the unclear status of many taxa and their rarity (Lacourt 2020). In Central Europe, however, only two species are known to be associated with *Betula*, *T. vitellina* and *T. lucorum* (Macek et al. 2020). The differences between the larvae of these two species are not yet clear, and barcoding is also of limited significance given the current state of taxonomic knowledge of the genus. The adults can be clearly distinguished by the colouration of the abdominal sterna and the lateral margins of the terga. These are completely black in *T. lucorum* (Figure 1D) and reddish brown in *T. vitellina* (Lacourt 2020; Macek et al. 2020) (Figure 1F).

Trichiosoma vitellina (Linnaeus, 1761)

Figures 1E–G, 2C

Material examined. SLOVAKIA – Banská Bystrica region • Kremnické vrchy Mts., Kremnické Bane (Zadná mokraď); 48°44′15.64″N, 018°53′47.26″V; 785 m alt.; 5.V.2021; LR lgt.; BOLD: UZINS092-22; 1♂, LR138_IZSAS.
LR138_IZSAS reared from the larva collected on 9.VIII.2020.

Distribution. Newly recorded from Slovakia. Palaearctic species. From the British Isles, through Central and Northern Europe, Mongolia, Russia to Siberia, North and South Korea, Japan.

Remarks. *Trichiosoma vitellina* is even more rarely collected than *T. lucorum* and is considered very local and rare in the Czech Republic (Macek et al. 2020) and strongly endangered in Germany (Liston et al. 2011). For Slovakia, only one historical record of *T. vitellina* from a single location is known so far (Poloniny Mountains, Sninský kameň) (Chyzer 1901). We reared a male of this species from a larva that we had collected by tapping branches of *Betula pubescens* in a swamp forest. This confirms the current occurrence of *T. vitellina* in Slovakia.

Identification. See the corresponding section on *T. lucorum*. The barcode of the male (BOLD record number UZINS092-22), which was reared from a *Betula*-fed larva (Figure 1G), could not be clearly assigned to species. The adults of *T. vitellina* are characterized by an abdomen with a reddish-brown ventral side (Macek et al. 2020) (Figure 1E, F).

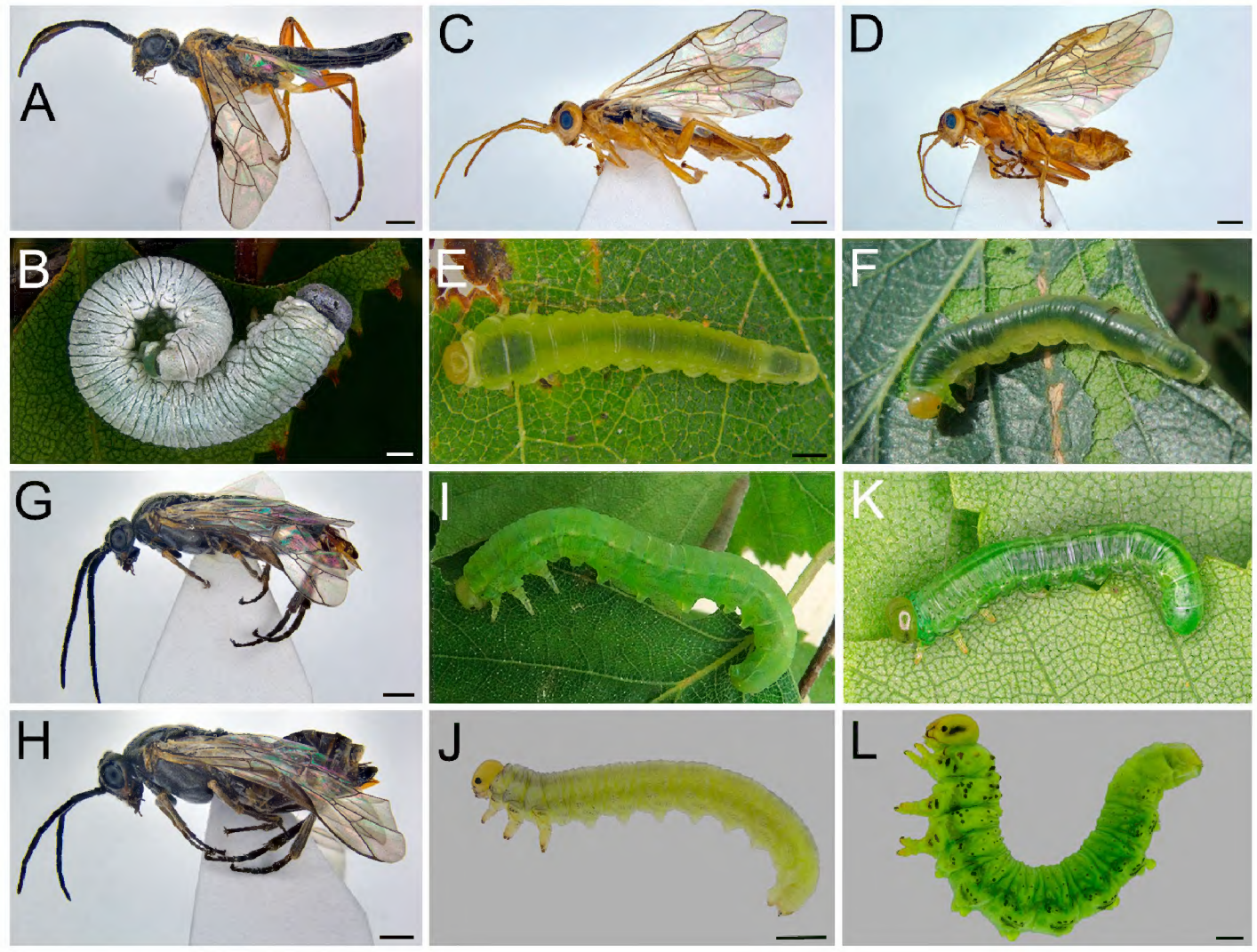

Figure 3. Adults and larvae of the species of *Allantus* Panzer, 1801, *Dineura* Dahlbom, 1835 and *Euura* Newman, 1837 found on birch trees in Slovakia. **A, B.** *Allantus cingillum* (Klug, 1818). **A.** Lateral view of the male. **B.** Dorsal view of the larva. **C–F**. *Dineura viridiorsata* (Retzius, 1783). **C.** Lateral view of the male. **D.** Lateral view of the female. **E.** Dorsal view of the larva. **F.** Lateral view of the larva and its typical window feeding on the surface of a birch leaf. **G–J**. *Euura ampla* (Konow, 1895). **G.** Lateral view of the male. **H.** Lateral view of the female. **I.** Mature feeding larva. **J.** Immature larva preserved in ethanol. **K, L.** *Euura leionota* (Benson, 1933). **K.** Dorsal view of the larva. **J.** Lateral view of the larva preserved in ethanol. Scale bars = 1 mm.

Family Tenthredinidae

***Allantus cingillum* (Klug, 1818)**
Figures 2D, 3A, B

Material examined. SLOVAKIA – Prešov region • Vysoké Tatry Mts.; Tatranská Lomnica; 49°9′50.53″N, 020°17′40.86″E; 813 m alt.; 17.VI.2023; LR lgt.; 1L, LR141_IZSAS – Banská Bystrica region • Kremnické vrchy Mts.; Kremnický štít; 48°41′45.53″N, 18°56′44.55″E; 952 m alt.; 1.V.2021; LR lgt.; 1♂, LR142_IZSAS • Kremnické vrchy Mts.; Kremnické Bane (Zadná mokraď); 48°44′15.64″N, 18°53′47.26”V; 785 m alt.; 7.VII.2024; LR lgt.; 2L, LR143_IZSAS.

LR142_IZSAS reared from the larva collected on 12.IX.2020.

Distribution. Newly recorded from Slovakia. Palaearctic species. Central and Northern Europe, Russia.

Remarks. This is a local and rare species in Central Europe (Roller and Haris 2008; Macek et al. 2020). In Slovakia, it is only known from historical records from the early 19th century (Roller and Haris 2008). We found this species in three separate *B. pubescens* stands and, thus, confirm the current occurrence of *A. cingillum* in Slovakia. The larvae occurred over a long period from June to September.

Identification. The adult of *A. cingillum* shows the following combination of features not present in other Central European species of the genus *Allantus* Panzer, 1801: an entirely black (♀) or white banded abdomen (♂), reddish posterior femora and tibia, an entirely black pterostigma, and a yellow labrum (Figure 3A). The larva differs from other *Allantus* larvae in Central Europe by its whitish, wax-dusted body, including the head, and by its host plant *Betula* sp. (Figure 3B; Macek et al. 2020).

***Dineura viridiorsata* (Retzius, 1783)**
Figures 3C–F, 4A

Material examined. SLOVAKIA – Banská Bystrica region • Kremnické vrchy Mts.; Kremnický štít; 48°41′45.53″N, 018°56′44.55″E; 952 m alt.; 12.IX.2020; LR lgt.; 2L, LR144_IZSAS • Kremnické vrchy Mts.; Kremnické Bane; 48°43′41.81″N, 018°54′26.66″E; 780 m alt.; 26.V.2022; LR lgt.; 1♂ and 1♀, LR147_IZSAS • Same locality as preceding; 3.IX.2023, LR lgt.; 1L • Same locality as preceding; 2.X.2023; LR lgt.; GenBank PP504955; 5L, S15_ DZFNSCU – Bratislava region • Borská nížina lowland; Mešterova lúka; 48°28′34.42″N, 017°3′31.90″E; 175 m alt; 15.IX.2020; LR lgt.; 2L, LR145_IZSAS • Borská nížina lowland; Orlovské Vŕšky; 48°27′49.15″N, 017°03′06.59″E; 182 m alt.; 6.X.2023; ŠM lgt.; 2L, LR146_IZSAS.

Distribution. First record from Slovakia. Palaearctic species. From Great Britain across Western, Central and Northern Europe, Russia to Siberia, China, Japan.

Remarks. This species seems to be one of the most common birch-feeding sawflies in Central Europe (Macek et al. 2020). We found its larvae in most of the birch stands surveyed, but only in late summer and early autumn (September–October). However, the population density was low, and only one or two larvae were found in about every tenth tree sampled.

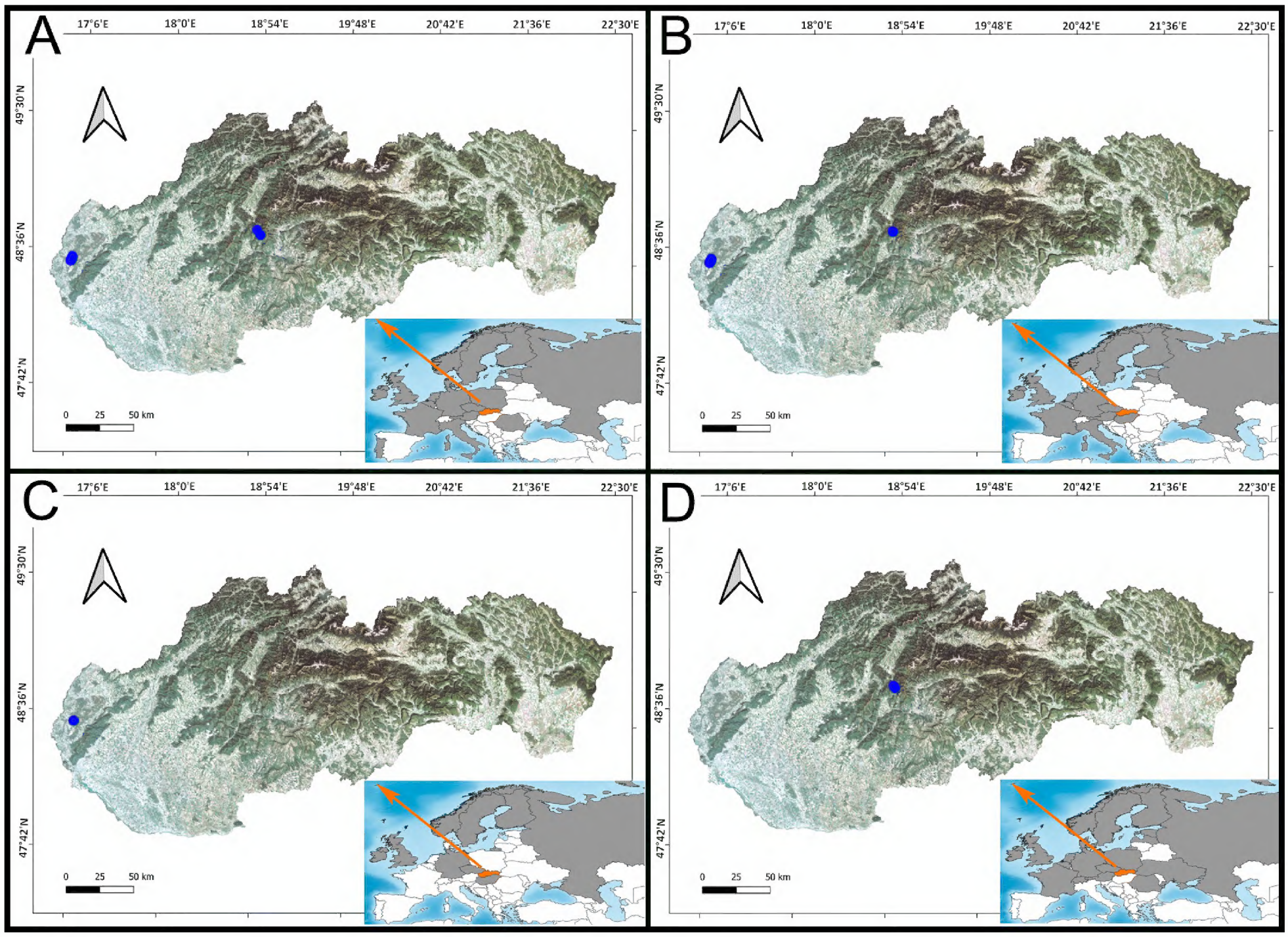

Figure 4. Geographical distribution of four Symphyta species in Europe with detailed distribution maps of Slovakia. **A.** *Dineura virididorsata* (Retzius, 1783). **B.** *Euura ampla* (Konow, 1895). **C.** *Euura leionota* (Benson, 1933). **D.** *Heterarthrus nemoratus* (Fallén, 1808). Countries with published record are highlighted in grey. New record (blue circle). Data from: Roller and Haris (2008); Taeger et al. (2018); Macek et al. (2022).

Identification. The adults of *D. virididorsata* can be easily distinguished from other European *Dineura* species, which all have a black head, by their predominantly yellow head (Lacourt 2020; Figure 3C, D). The larvae of *Dineura* Dahlbom, 1835 are characterized by a dorsoventrally flattened and posteriorly tapering body in combination with their occurrence on leaves from late summer to autumn. *Dineura virididorsata* is the only representative of *Dineura* that feeds on *Betula* in Europe. It can be distinguished from similar larvae of *Nematinus* Rohwer, 1911, which also occur on *Betula*, by its uniform green colouring and the abdominal segments divided into 6 annulets (Figure 3E, F; Macek et al. 2020). The barcode of one larva (GenBank accession PP504955) also confirmed our identification.

Euura ampla (Konow, 1895)

Figures 3G–J, 4B

Material examined. SLOVAKIA – Bratislava region • Borská nížina lowland; Mešterova lúka; 48°28′34.42″N, 017°03′31.90″E; 175 m alt.; 13.V.2023; LR lgt.; GenBank PP504899; 2L, 3♀, S07_DZFNSCU • Borská nížina lowland; Orlovské vŕšky; 48°27′49.15″N, 017°03′06.59″E; 182 m alt.; 21.V.2022; LR lgt.; 2L, 1♂, 3♀, LR147_IZSAS • Same locality as preceding; 1.V.2023; LR lgt.; GenBank PP505416, PP505436, PP511295, PP511296; 8L, S17,S19, S20, S26_ DZFNSCU – Banská Bystrica region • Kremnické vrchy Mts.; Kremnické Bane (Zadná mokraď); 48°44′15.64″N, 018°53′47.26″V; 785 m alt.; 28.V.2022; LR lgt.; 1L, 4♀, LR148_IZSAS • Same locality as preceding; 3.VI.2023; LR lgt.; 3L, 1♂, LR149_IZSAS.

S07_DZFNSCU 3♀ reared from larvae in III.2024. LR147_IZSAS 1♂ and 3♀ reared from larvae on 15-17. III.2023. LR148_IZSAS 4♀ reared from larvae on 15-17.III.2023. LR149_IZSAS Kremnické Bane 1♂ reared from larva in III.2024.

Distribution. First complete record for Slovakia. Palaearctic species. From the British Isles across Central, Northern and Eastern Europe, Russia to Siberia.

Remarks. *Euura ampla* is common and widespread in the Czech Republic (Macek et al. 2020). However, the adults are rarely collected as they occur in early spring, but the larvae could be found regularly on fresh birch

leaves. We found them in all *B. pubescens* stands investigated in May. Here we present the first records with details of the specimens, the location and date of collection from Slovakia. This species was only mentioned for Slovakia in the checklist published by Beneš (1989) but without detailed faunistic data.

Identification. Adults of *E. ampla* can be clearly distinguished by the external morphology and the shape of the penis valve, as described and illustrated by Macek et al. (2020) and Lacourt (2020) (Figure 3G, H). The larva is characterized by a green body with very fine black tubercles, a light-coloured head without black markings and an anal segment without appendages in the fully grown larva (Figure 3I; Macek et al. 2020). However, it can be confused with the larva of *E. aegra* (Konow, 1895), and, therefore, its rearing to adulthood, or barcoding is recommended. The identification of the larvae was also confirmed by the barcodes obtained (GenBank accessions PP504899, PP505416, PP505436, PP511295, PP511296).

Euura leionota (Benson, 1933)

Figures 3K, L, 4C

Material examined. SLOVAKIA – Bratislava region • Borská nížina lowland; Mešterova lúka; 48°28′34.42″N, 017°03′31.90″E; 175 m alt.; 1.V.2023; LR lgt.; 2L, LR151,152_IZSAS • Same locality as preceding; 13.V.2023; LR lgt.; GenBank PP912109; 3L, LR153,154,155_IZSAS.

Distribution. New record from Slovakia. Palaearctic species. Northern, Western and Central Europe. Besides Slovakia confirmed for Finland, Norway, Sweden, and the United Kingdom by Prous et al. (in press). Other country records need confirmation.

Remarks. *Euura leionota* was possibly reported as *Euura connecta* (Lindqvist, 1958) from two birch stands in Slovakia, one in the Borska nížina lowland and the other in the Kremnické vrchy Mountains (Roller and Macek 2017). We confirmed this hypothesis by barcoding freshly collected larvae from the population in Borska níži-na. This species is rare in Central Europe and apart from the host plant, very little is known about its biology. We tapped larvae from the branches of 3- to 4-m-high trees of *B. pubescens* in the undergrowth of older pine–birch forest. The larvae occurred in very low densities and only in May, suggesting that the species is univoltine and prefers sheltered sites for the development of its solitary larvae.

Identification. The larvae identified here as *E. leionota* were previously reported and illustrated as *Nematus connectus* (Lindqvist, 1958) by Roller and Macek (2017) and Macek et al. (2020) based on the external mor-phology of the reared adult. However, the larva of *E. connecta* does not feed on *Betula*, but on *Salix* leaves (Prous et al. in press). One of the collected larvae was barcoded, which clearly identified it as *Euura leionota* (GenBank accession PP912109). It differs only slightly in colouration and external morphology (Figure 3K, L) from the larvae of several other *Euura* Newman, 1837 species, which also feed on fresh *Betula* leaves in early spring. For an exact identification of the larva, its rearing to adulthood or barcoding is recommended.

Heterarthrus nemoratus (Fallén, 1808)

Figures 4D, 5A, B

Material examined. SLOVAKIA – Banská Bystrica region • Kremnické vrchy Mts.; Kremnické Bane; 48°43′41.81″N, 018°54′26.66″E; 780 m alt.; 21.VII.2020; LR lgt.; 2L, LR163_IZSAS • Kremnické vrchy Mts.; Jas-trabá; 48°38′40.34″N, 018°55′27.69″E; 490 m alt.; 27.VII.2020; LR lgt.; PP511298; 1L, S21_ DZFNSCU • Krem-nické vrchy Mts.; Kremnica env.; 48°41′45.43″N, 018°55′13.25″E; 612 m alt.; 8.VIII.2018; LR lgt.; 1L, LR164_IZ-SAS • Kremnické vrchy Mts.; Kremnické Bane (Zadná mokraď); 48°44′15.64″N, 018°53′47.26″E; 785 m alt.; 21.VII.2024; LR lgt.; GenBank PQ334006; 1L, S35_ DZFNSCU.

Distribution. First record from Slovakia. Holarctic species. Europe, Great Britain, Ireland, Ukraine, Russia, introduced to North America (Canada, USA).

Remarks. This leafminer is local and uncommon in Central Europe, as also in the Czech Republic (Macek et al. 2020). We found only a few leaf mines on *Betula pendula* trees in various stands at medium altitudes in the Kremnické vrchy Mountains. The species is parthenogenetic with late emergence of adults and rather long development of larvae (Liston et al. 2019b). We collected larvae in the mines only from mid-July to mid-August.

Identification. The larvae of *Heterarthrus* Stephens, 1835 can be clearly distinguished from other leaf-fee-ding Tenthredinidae by their external morphology (Lorenz and Kraus 1957). At the species level, the larvae of *Heterarthrus* show rather small differences, but in combination with their host plant and best with the barcode, the European species can be identified. *Heterarthrus nemoratus* is the only known representative of this genus whose host plant is *Betula* (Liston et al. 2019b). The leaf mine of *H. nemoratus* also has a typical appearance, starting from the leaf margin, and with the oldest part of the mine brownish (Macek et al. 2020; Figure 5B). The barcode of the collected larva (GenBank accession PQ334006) clearly showed that it belongs to *H. nemoratus*.

Nematinus caledonicus (Cameron, 1882)

Figures 5C, D, 6A

Material examined. SLOVAKIA – Banská Bystrica region • Kremnické vrchy Mts.; Kremnické Bane (Zadná mokraď); 48°44′15.64″N, 018°53′47.26″V; 785 m alt.; 3.IX.2023; LR lgt.; PP504916; 1L, S09_ DZFNSCU.

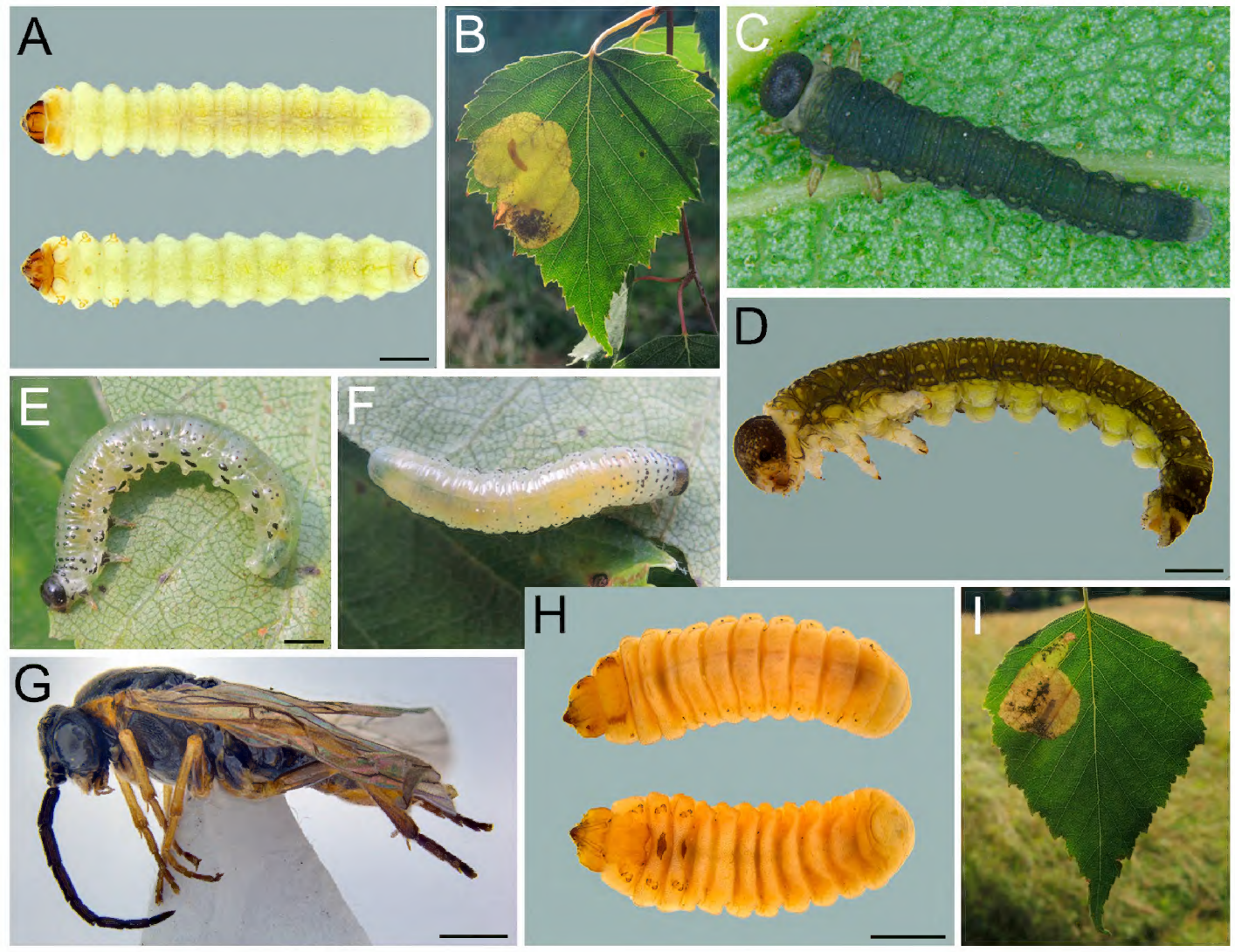

Figure 5. Adults and larvae of the species of *Heterarthrus* Stephens, 1835, *Nematinus* Rohwer, 1911, *Pristiphora* Latreille, 1810 and *Profenusa* MacGillivray, 1914 found in birch trees in Slovakia. **A, B.** *Heterarthrus nemoratus* (Fallén, 1808). **A.** Dorsal and ventral views of the larva preserved in ethanol. **B.** Leaf mine with the medium-sized larva. **C, D**. *Nematinus caledonicus* (Cameron, 1882). **C.** Dorsal view of the larva. **D.** Lateral view of the larva preserved in ethanol. **E–G.** *Pristiphora alpestris* (Konow, 1903). **E.** Lateral view of the larva. **F.** Dorsal view of the larva. **G.** Lateral view of the male. **H, I.** *Profenusa thomsoni* (Konow, 1886). **H.** Dorsal and ventral views of the larva preserved in ethanol. **I.** Leaf mine with the medium-sized larva. Scale bars = 1 mm.

Distribution. First record from Slovakia. Palaearctic species. Great Britain, Ireland, Finland, Sweden, Germany, Czech Republic, and Russia to Siberia.

Remarks. *Nematinus caledonicus* is apparently very rare and locally distributed in Central Europe. The sparse records come from northern regions and mountains (Taeger et al. 1989; Macek et al. 2020). We only collected a single medium-sized larva in a birch swamp forest. Remarkably, the tree of *B. pubescens* from which the larva was tapped had rather low-quality leaves in the process of leaf fall.

Identification. The larva of this species can be easily recognized by its colouring and occurrence late in the season. It is the only larva that has a black head and a dorsally grey-black body and feeds on *Betula* leaves in the late vegetation period. It also differs from similar dorsoventrally flattened larvae of *Dineura* by the abdominal segments divided into five annulets (Figure 5C, D; Macek et al. 2020). *Nematinus caledonicus* also has distinctive barcodes (barcode index number of BOLD: AAQ4001), which was confirmed by barcoding the collected larva (GenBank accession PP504916).

***Pristiphora alpestris* (Konow, 1903)**
Figures 5E–G, 6B

Material examined. SLOVAKIA – Bratislava region • Borská nížina lowland; Orlovské vŕšky; 48°27′49.15″N, 017°03′06.59″E; 182 m alt.; 1.V.2023; LR lgt.; PP504915; 3L, S08_ DZFNSCU • Borská nížina lowland; Mešterova lúka; 48°28′34.42″N, 17°03′31.90″E; 175 m alt.; 13.V.2023; LR lgt.; 1L, LR158_IZSAS – Banská Bystrica region • Kremnické vrchy Mts.; Kremnické Bane (Zadná mokraď); 48°44′15.64″N, 018°53′47.26”V; 785 m alt.; 3.VI.2023; LR lgt.; 3L • Same locality as preceding; IV.2024; LR lgt.; 1♂, LR159_IZSAS.

LR159_IZSAS reared from the larva collected on 3.VI.2023.

Distribution. First record from Slovakia. Palaearctic species. Great Britain, Northern, Western and Central Europe, Russia.

Remarks. It was first mentioned by Roller (1999) in the checklist of sawflies of Slovakia; however, this was a misidentification. According to Macek et al. (2020), *Pristiphora alpestris* is common and widespread in the Czech Republic. However, the adults of this univoltine species are rarely collected, as they occur only in small numbers and in early spring. We recorded larvae of this species at two sites in the lowlands and in a mountain stand of *B. pubescens*. The larvae were tapped very sporadically from twigs with fresh birch leaves in May to early June.

Identification. The larva of *P. alpestris* is unique among the Slovakian *Pristiphora* Latreille, 1810 species due to its colouration in combination with its host specificity. It is the only phyllophagous larva on *Betula* with a predominantly black head and numerous black tubercles, as well as black surpedal and subspiracular lobes on the yellowish-green body (Figure 5E, F; Macek et al. 2020). Its early occurrence in spring is also characteristic, as the larva feeds on very fresh leaves. A male reared from a larva was identified by the unique shape of the penis valve, as shown in the key by Prous et al. (2017) (Figure 5G). The barcode of one of the larvae (GenBank accession PP504915) confirmed this identification.

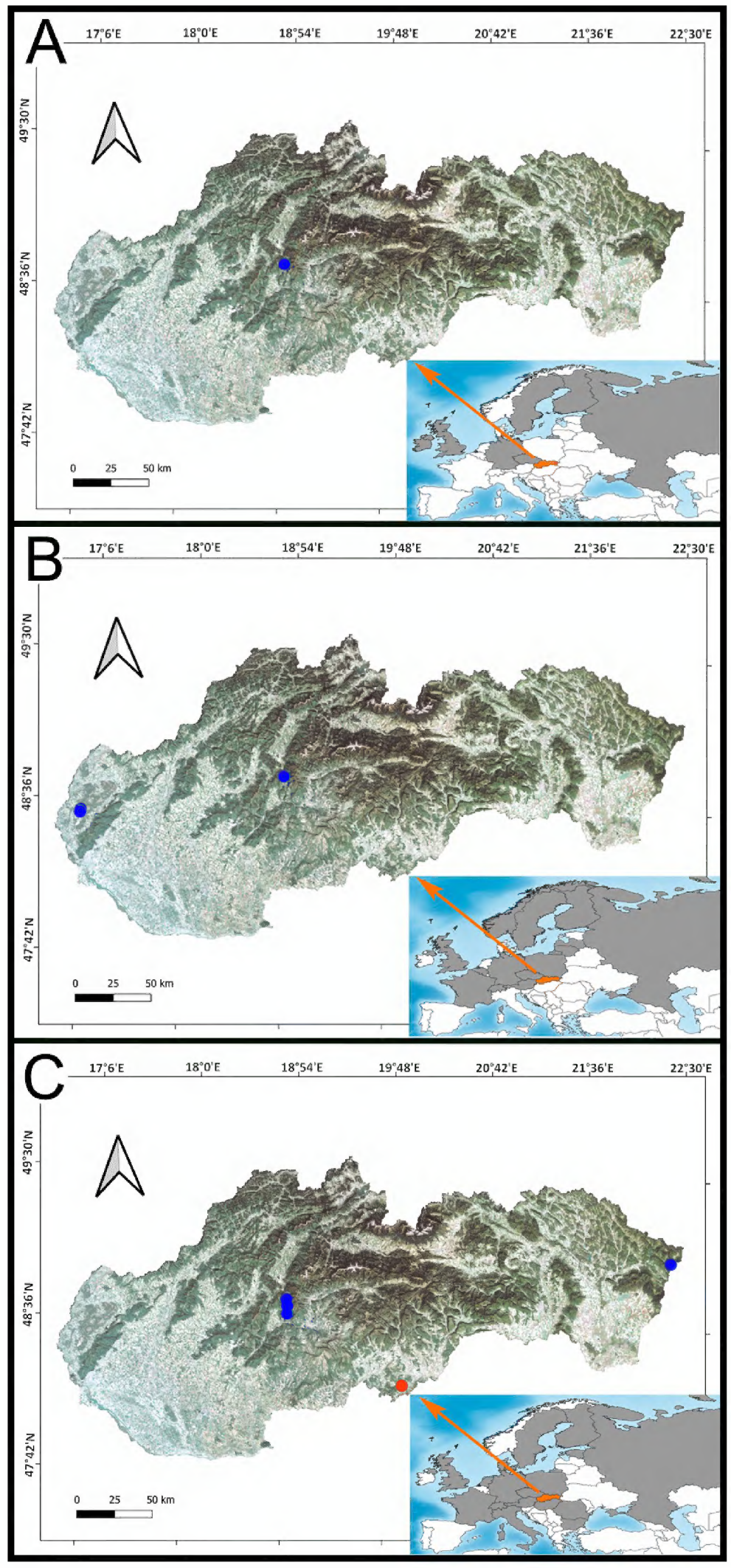

Figure 6. Geographical distribution of three Symphyta species in Europe with detailed distribution maps of Slovakia. **A.** *Nematinus caledonicus* (Cameron, 1882). **B.** *Pristiphora alpestris* (Konow, 1903). **C.** *Profenusa thomsoni* (Konow, 1886). Countries with published record are highlighted in grey. Previously published record (red circle). New record (blue circle). Data from: Roller and Haris (2008); Taeger et al. (2018); Macek et al. (2022).

***Profenusa thomsoni* (Konow, 1886)**
Figures 5H, I, 6C

Material examined. SLOVAKIA – Banská Bystrica region • Kremnické vrchy Mts.; Jastrabá; 48°38′40.34″N, 018°55′27.69″E; 490 m alt.; 27.VII.2020; LR lgt.; PP504898; 5L, S08_ DZFNSCU • Kremnické vrchy Mts.; Kremnické Bane; 48°43′41.81″N, 018°54′26.66″E; 780 m alt.; 21.VII.2020; LR lgt.; 1L, LR160_IZSAS • Kremnické vrchy Mts.; Kremnica; 48°41′45.43″N, 018°55′13.25″E; 612 m alt.; 31.VIII.2020; LR lgt.; 1L, LR161_IZSAS – Prešov region • Poloniny Mts.; Uličské Krivé; 48°59′10.02″N, 022°26′58.96″E; 350 m alt.; 1.VIII.2021; LR lgt.;1L, LR162_IZSAS.

Distribution. New evidence for Slovakia. Mainly in the Palaearctic (Great Britain, Ireland, Europe, Russia, Japan), but also introduced to North America (Canada, USA).

Remarks. This leaf miner occurs late in the season, in summer; its males are unknown, and it is uncommon and locally distributed in the Czech Republic. There has been no evidence of its occurrence in Slovakia for a

long time (Macek et al. 2020). The first female of *P. thomsoni* was only recently recorded in Slovakia at the edge of a thermophilic and basophilic oak forest in the Cerová vrchovina Mountains (Balázs and Haris 2023). We found mines with larvae of *P. thomsoni* in open parts of the crowns of *B. pubescens* in several stands in the mountains of Central and Eastern Slovakia.

Identification. A *Betula* leaf inhabited by immature *P. thomsoni* can be recognized by the combination of the shape of the mine and the morphology of the larva. A blotch mine starts near the center of the leaf and spreads over the main veins (Figure 5I). The larva has reduced thoracic legs, similar to the larva of *Heterarthrus nemoratus*, but differs by a rounder body and a light-coloured head and first thoracic segment (compare Figure 5H to 5A). The barcode of one of the recorded larvae (GenBank accession PP504898) confirmed the identification.

DISCUSSION

Birches (*Betula* sp.) are common and widespread trees that grow in, or dominate, a variety of habitats. They also harbour one of the most species-rich Symphyta faunas of the Western Palaearctic (Lacourt 1999; Nyman et al. 2010). A total of 58 species are known to feed on birch leaves or bore into their wood in Europe (Lacourt 2020; Macek et al. 2020). However, this assemblage has not yet been methodically studied in Slovakia and only occasional and often only historical records of the birch Symphyta are available (Roller and Haris 2008; Roller and Macek 2017; Macek et al. 2020). The reasons for this scarce knowledge could be the low population density, which contrasts with the abundance of host plants, as well as the temporally limited occurrence of adults. Therefore, the main sampling method in this study was collection of larvae, that occur over a longer period of 2–4 weeks, which allowed us to record the species more efficiently. The larvae of most reported species were sampled regularly, albeit at low densities of about 1–3 larvae per 10 sampled trees. In this way, we were also able to collect species (*A. cingillum*, *E. leionota*, *N. caledonicus*, and *T. vitellina*) that are considered rare or very rare in Central Europe (Taeger et al. 1998; Macek et al. 2020).

Here, we provide new data on the distribution of 11 species that are phyllophagous on birch trees. Species-specific aspects of our records are commented on in the remarks section for each species. In general, all species were found within their expected distribution range, which corresponds to the original distribution range of European birches. In addition, we provide information on the biology of some species including the very rare *Euura leionota* with a single distribution record in Slovakia. This species was incorrectly identified in a previous study (Roller and Macek 2017) as *Nematus connectus* (Lindqvist, 1957), which should be removed from the list of Symphyta of Slovakia.

According to our results, the number of sawfly species feeding on birch trees in Slovakia has increased from 41 to 46. Thus, the total diversity of Symphyta in Slovakia has increased to 700 recorded species. However, there are still some species that apparently continually evade detection. Comparing the Slovak fauna with the fauna of neighbouring countries (Zhelochovtsev and Zinovjev 1995, 1996; Huflejt 1997; Roller and Haris 2008; Macek et al. 2020), one might still expect the discovery of nine birch associated species: *Arge expansa* (Klug, 1834), *Euura aegra* (Konow, 1895), *E. berolinensis* (Muche, 1970), *E, brevivalvis* (Thomson, 1871), *E. cadderensis* (Cameron, 1875), *Nematus princeps* (Zadach, 1876), *Praia taczanowskii* Wankowicz 1880, *Pristiphora pseudocoactula* (Lindqvist, 1952), and *Xiphydria betulae* (Enslin, 1911). The biology of all are little-known, and they are very rare in Central Europe. To confirm their occurrence in Slovakia, systematic sampling in various birch stands is required.

ACKNOWLEDGEMENTS

LR thanks Ľubomír Vidlička (Bratislava) for his support in taking and post-processing microscope images. ŠM would like to thank Samuel Krčmárik (Bratislava) for guidance on barcoding laboratory methods and sequence analysis. We are also grateful to the anonymous reviewers whose comments and suggestions significantly improved the manuscript.

ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

Funding

This study was financially supported by project no. 2/0070/23 of the Slovakian grant agency VEGA and by the Operational Programme for Research and Innovation co-financed by the European Regional Development Fund (ERDF) ITMS2014 + 313021 W683: "DNA Barcoding of Slovakia (SK-BOL), as part of the international initiative International Barcode of Life (iBOL)".

Author contributions

Conceptualization: LR. Data curation: LR, MP, ŠM. Formal analysis: JM, LR, MP, ŠM. Funding acquisition: LR. Investigation: LR, ŠM. Methodology: JM, LR, MP. Resources: LR, ŠM. Supervision: LR. Visualization: LR. Project administration: LR. Validation: JM, LR, MP, ŠM. Writing – original draft: LR, ŠM. Writing – review and editing: LR, JM, MP, ŠM.

Author ORCID iDs

Marko Prous https://orcid.org/0000-0002-5329-7608
Ladislav Roller https://orcid.org/0000-0002-9824-2096

Data availability

All data that support the findings of this study are available in the main text.

REFERENCES

Atlas krajiny Slovenskej Republiky (2013) Slovenská agentúra životného prostredia. Centrum environmentálnej informatiky. http://geo.enviroportal.sk/atlassr/. Accessed on: 2024-07-16.

Balázs A, Haris A (2019a) Three species of sawflies (Symphyta: Pamphiliidae, Argidae, Tenthredinidae) new for the fauna of Slovakia. MendelNet 6–7 November 2019: 243–247.

Balázs A, Haris A (2019b) Sawflies (Hymenoptera: Symphyta) of Cerová vrchovina Upland (South Slovakia). Natura Somogyiensis 33: 61–74. https://doi.org/10.24394/natsom.2019.33.61

Balázs A, Haris A (2023) New sawfly (Hymenoptera: Symphyta) data from southern Slovakia. Natura Somogyiensis 41:101–120. https://doi.org/10.24394/natsom.2023.41.101

Beneš K (1989) Symphyta. In: Šedivý J (Ed.) Enumeratio Insectorum Bohemoslovaciae – Checklist of Czechoslovak Insects III. Acta Faunistica Entomologica Musei Nationalis Pragae, Kunratice-Praha, Praha, Czech Republic, 13–25.

Chyzer K (1900) Zemplén megye Hymenopterái. I. Fam. Tenthredinidae. Rovartani Lapok 8 (9): 184–186.

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Goulet H, Boudreault C, Schiff NM (2015) Revision of the world species of *Xeris* Costa (Hymenoptera: Siricidae). Canadian Journal of Arthropod Identification 28: 1–101. https://doi.org/10.3752/cjai.2015.28

Holý K, Bogusch P, Janšta P, Macek J, Roller L, Straka J, Werner P (2016) Aktuálni počet druhů blanokřídlých v ČR a SR a míra prozkoumanosti jednotlivých čeledí. In: Blanokřídli v českých zemích a na Slovensku, Horka nad Moravou, Czech Republic, 14–17.

Huflejt T (1997) Symphyta - Rośliniarki. In: Razowski J (Ed.) Wykaz zwierzat Polski. Wydawnictwa Instytutu Systematyki i Ewolucji Zwierząt PAN, Krakow, Poland, 7–42.

Kúdelová T, Krčmárik S, Lužáková I, Bujačková B, Matická K, Kúdela M (2022) DNA barcoding of black flies (Diptera: Simuliidae) in Slovakia and its utility for species identification. Diversity 15: 1–17. https://doi.org/10.3390/d15050661

Lacourt J (1999) Répertoire des Tenthredinidae ouest-paléarctiques. Mémoires de la SEF, Paris 3: 1–432.

Lacourt J (2020) Sawflies of Europe. Hymenoptera of Europe 2. N.A.P. Editions, Verrières-le-Buisson, France, 800pp.

Liston A, Prous M, Macek J (2019a) On Bulgarian sawflies, including a new species of *Empria* (Hymenoptera, Symphyta). Deutsche Entomologische Zeitschrift 66 (1): 85–105. https://doi.org/10.3897/dez.66.34309

Liston A, Mutanen M, Viitasaari M (2019b) On the taxonomy of *Heterarthrus* (Hymenoptera, Tenthredinidae), with a review of the West Palaearctic species. Journal of Hymenoptera Research 72: 83–126. https://doi.org/10.3897/jhr.72.39339

Liston AD, Jansen E, Blank SM, Kraus M, Taeger A (2011) Rote Liste und Gesamtartenliste der Pflanzenwespen (Hymenoptera: Symphyta) Deutschlands. In: Binot-Hafke M, Balzer S, Becker N, Gruttke H, Haupt H, Hofbauer N, Ludwig G, Matzke-Hajek G, Strauch M (Eds.) Rote Liste gefährdeter Tiere, Pflanzen und Pilze Deutschlands. Band 3: Wirbellose Tiere (Teil 1). Landwirtschaftsverlag, Germany, 491–556.

Lorenz H, Kraus M (1957) Die Larvalsystematik der Blattwespen (Tenthredinoidea und Megalodontoidea). Akademie-Verlag, Berlin, Germany, 339pp.

Macek J, Roller L, Beneš K, Holý K, Holuša J (2020) Blanokřídlí České a Slovenské Republiky II., Academia, Praha, Czech Republic, 680 pp.

Natural Earth (2024) http://www.naturalearthdata.com. Accessed on: 2024-07-15.

Nyman T, Vikberg V, Smith DR, Boevé JL (2010) How common is ecological speciation in plant-feeding insects? A 'Higher' Nematinae perspective. BMC Evolutionary Biology 10: 266. https://doi.org/10.1186/1471-2148-10-266

Prous M, Kramp K, Vikberg V, Liston A (2017) North-western Palaearctic species of *Pristiphora* (Hymenoptera, Tenthredinidae). Journal of Hymenoptera Research 59: 1–190. https://doi.org/10.3897/jhr.59.12656

Prous M, Liston A, Monckton SK, Kramp K, Vårdal H, Vikberg V, Heibo E, Mutanen M (in press) West Palaearctic species of *Euura* Newman, 1837 (Hymenoptera, Tenthredinidae). European Journal of Taxonomy.

QGIS.org. (2024) http://www.qgis.org. GIS Geographic Information System. QGIS Association. Accessed on: 2024-06-12.

Roller L (1999) Checklist of the sawflies (Hymenoptera, Symphyta) of Slovakia. Entomological Problems 30 (2): 37–48.

Roller L, Haris A (2008) Sawflies of the Carpathian Basin, history and current research. Natura Somogyiensis 11: 1–261.

Roller L, Kočíšek J (2023) A new species of *Mesoneura* (Hymenoptera, Tenthredinidae) associated with xerothermic oak forest in the Western Carpathians, Slovakia. Journal of Hymenoptera Research 95: 261–274. https://doi.org/10.3897/jhr.95.100689

Roller L, Macek J (2017) Prvonálezy hrubopásych blanokrídlovcov (Hymenoptera, Symphyta) na Slovensku. Entomofauna Carpathica 29 (1): 53–63.

Roller L, Macek J, Kočíšek J (2022) Sawflies (Hymenoptera, Symphyta) in natural stands of Osier willow (*Salix viminalis*) in south-western Slovakia. Entomofauna Carpathica 34 (1): 41–60.

Taeger A, Liston AD, Prous M, Groll EK, Gehroldt T, Blank SM (2018) ECatSym – Electronic World Catalog of Symphyta (Insecta, Hymenoptera). Program version 5.0 (19 Dec 2018), data version 40 (23 Sep 2018). Senckenberg Deutsches Entomologisches Institut (SDEI), Müncheberg. https://sdei.de/ecatsym/. Accessed on: 2024-03-20.

Taeger A, Altenhofer E, Blank SM, Jansen E, Kraus M, Pschorn-Walcher H, Ritzau C (1998) Kommentare zur Biologie, Verbreitung und Gefährdung der Pflanzenwespen Deutschlands (Hymenoptera, Symphyta). In: Taeger A, Blank SM (Eds.) Pflanzenwespen Deutschlands (Hymenoptera, Symphyta). Kommentierte Bestandsaufnahme. Goecke & Evers, Keltern, Germany, 49–135.

Zhelochovtsev AN, Zinovjev AG (1995) Список пилильщиков и рогохвостов (Hymenoptera, Symphyta) фауны России и сопредельных территорий I [A list of the sawflies and horntails (Hymenoptera, Symphyta) of the fauna of Russia and adjacent territories I]. Entomologicheskoe Obozrenie 74: 395–415. [in Russian]

Zhelochovtsev AN, Zinovjev AG (1996) Список пилильщиков и рогохвостов (Hymenoptera, Symphyta) фауны России и сопредельных территорий II [A list of the sawflies and horntails (Hymenoptera, Symphyta) of the fauna of Russia and adjacent territories II]. Entomologicheskoe Obozrenie 75: 357–379. [in Russian]